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Racial/Ethnic Differences in the Association between the Joint Occurrence of Obesity, Physical Inactivity and Type 2 Diabetes among US Adults

Chiamaka Anyanele

ABSTRACT

RACIAL/ETHNIC DIFFERENCES IN THE ASSOCIATION BETWEEN THE JOINT OCCURRENCE OF OBESITY, PHYSICAL INACTIVITY AND TYPE 2 DIABETES AMONG US ADULTS

By

CHIAMAKA A. ANYANELE

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Background: Type 2 diabetes is the second leading cause of death in the United States. Obesity and physical inactivity are positively associated with increased risk of type 2 diabetes. However, little information is known about how these two risk factors coexist to influence Type 2 diabetes across different racial/ethnic groups (Non-Hispanic Blacks, Non-Hispanic Whites and Mexican Americans). Understanding the relationship in the joint occurrence of obesity and physical inactivity with the risk of diabetes is of importance in framing robust public health interventions to alleviate health disparities in the US.

AIM: To examine the association of the joint occurrence of obesity and physical inactivity with Type 2 diabetes in adults 18 years old or greater stratified by race.

Methods: A nationally representative data (N=5992), the 2015-2016 wave of the National Health and Nutritional Examination Survey (NHANES) including adults aged 18-65+ years was used for this study. Chi square tests and logistic regression were used to determine the joint occurrence of the two risk factors with type 2 diabetes by proportion and the odds ratio across racial groups respectively. Diabetes was defined as a history of a prior diagnosis of diabetes, use of diabetes medication or Glycohemoglobin (A1c) of 6.5% or higher.

Results: The prevalence of diabetes was observed to be higher among Non-Hispanic blacks (37.52%) than Mexican Americans (29.72%) and Non-Hispanic Whites (24.36%). Increased number of risk factors was associated increased odds of diabetes among these ethnic groups. In the joint association of obesity and physical inactivity was associated with increased odds of type 2 diabetes in NHW (OR=1.81; 95% CI=1.11-2.97), NHB (OR: 2.33; 95% CI=1.74-3.11) and MA (OR=1.70 95% CI=1.12-2.59) after adjusting for age, gender, educational level, income, diet and smoking

Conclusion: The positive significant association between the joint occurrence of obesity and physical inactivity with increased risk of type 2 diabetes has a public implication. The results call for diabetes intervention tailored toward addressing the co-occurrence of obesity and physical inactivity.

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APPROVAL PAGE

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Author’s Statement Page

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TABLE OF CONTENTS

List of Tables

1.1- Introduction

Background of Type 2 diabetes

Diabetes is a disease characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action or both (Kharroubi, 2015). Type 2 diabetes (T2D), which makes up at least 90% of diabetes cases, mostly occurs in adulthood and is associated with other metabolic disorders and an increased burden of morbidity and mortality rate (Kharroubi, 2015).

Ethnicity and obesity are independent risk factors of Type 2 diabetes (T2D). In the last 3 years, there has been changes in the racial and weight distribution among adults in the US. In 2004, the prevalence of diabetes in the US increased among Blacks and Hispanics than Whites across all age-groups. Between ages 45-64 years, the prevalence among whites was 7.8%, 13.5% among Hispanics and 15.4% among Blacks (Shai, Jiang et al, 2006). These groups are more likely to be overweight/obese and are at risk of high blood pressure.

The prevalence of T2D is widely increasing not only in the US, but also in developed and low to middle-income families such as Japan, Brazil, and Pakistan etc (Wu, Ding, 2014). This chronic illness is projected to increase progressively over the next 20 years, with more than 70% occurring at developing countries (Wu, Ding 2014). T2D and obesity are associated with insulin resistance (Kharroubi, 2015).

According to the Centers for Diseases Control and Prevention (CDC), the prevalence of obesity in the US was 39.8% between 2015-2016 (CDC, 2017). The association tends to differ by age, socioeconomic status (SES) and ethnicity. Racial/ethnic minorities comprises of 36.3% of the US population and are expected to increase to more than 50% of the US population by 2050 (Wang et al, 2015). There has been a disproportionate increase in the prevalence of obesity typically among Whites. The past three decades have been an influx of young Hispanic immigrants and this has resulted in the prevalence of obesity across all ethnic groups. (Wang et al, 2007).

Epidemiological Comparison of Obesity and Physical Inactivity

Type 2 diabetes or hyperglycemia occurs due to effects in insulin secretion. This chronic condition can cause long-term damage and majorly failure of the internal organs such as kidneys, blood vessels etc (WHO, 2019). T2D has become the second leading cause of death in the United States. Statistics show that it accounts for 95% of the 25.8 million diabetic cases in the US (ASMBS, 2013).

Physical inactivity is associated with an increased risk of T2D. The American Heart Association recommends that obese individuals should engage in moderate to intense physical activity for either 30 minutes, 5 days a week or vigorous physical activity that lasts for 20 minutes, 3 days/wk. However, obese individuals suffer from social, psychological or social barriers

that prevent them from performing the recommended level of physical activity (Hills et al, 2010). Furthermore, there are ongoing clinical investigations to understand the effect of physical inactivity on obesity.

Certain nutritional factors such as reduced intake in vitamin B12 are associated with lower levels of physical activity and might play a part in increasing the risk of diabetes among different population groups such as South Asian children in the UK (Banerjee et al 2005).

1.2 Objective of Study

The objective of this study is to examine the joint occurrence of obesity, physical inactivity and type 2 diabetes among racial groups among US adults who are over the age of 18 years using NHANES 2015-2016

1.3 Research Question/Gap in Literature

Obesity and physical inactivity serve as predictors for Type 2 diabetes among individuals residing in the United States. The overarching goal of this study is to identify the joint occurrence of these risk factors with the prevalence of type 2 diabetes stratified by race and to suggest future recommendations/research on these racial populations.

Aim 1: To determine the prevalence in the coexistence of obesity, physical inactivity and diabetes in the US across racial groups

Aim 2: To determine the joint occurrence of obesity and physical inactivity with the risk of type-2 diabetes stratified by race among US adults

Chapter II **- Literature Review**

2.1 Obesity and Type 2 diabetes

Several studies have examined the disparities in the prevalence of diabetes among racial/ethnic groups by obesity status. (Zhang, 2009) conducted a cross-sectional study in California to examine the racial/ethnic differences in the prevalence of diabetes stratified by obesity status. Participants were selected from NHANES 1971-2004 NHANES data. After adjusting for age, gender, education and self-reported diagnosis showed an increased odds ratio (OR) for Mexican Americans from 1.1-2.1 while among Blacks, OR increased from 1.4-2.1 with a variance in BMI groups. There was no increase in the odds ratio for obese groups. In undiagnosed groups using Fasting plasma glucose (FPG), there was a reduction in minority groups except blacks.

Another study conducted in Pennsylvania using the MedMining Database from Geisinger health care system estimated that individuals with obesity categories were likely to be diagnosed with T2D compared with normal BMI with $p<0.01$. Since there is an association with those who have diabetes, individuals along with their physicians are monitoring their BMI and other clinical biomarkers to prevent the risk of developing T2D (Ganz et al, 2014)

Prospective studies have shown that the risk of type 2 diabetes is gradually increasing among individuals with BMI $\geq 30 kg/m^2$ after adjusting for age, smoking, family history of diabetes. Obesity occurs more in Black than White populations and these differences are even observed among young age groups. For instance, the prevalence of obesity among school children was 21% among Whites boys compared to the prevalence of 26% and 38% among Black boys and girls respectively (Khan et al, 2004). Ethnic differences in either lifestyle or economic factors might also have an influence in disease outcomes or diseases related to obesity.

2.2 Physical Activity

Physical activity is defined as body movement produced due to contraction of skeletal muscle and requires a lot of energy (Sigal, 2004). Exercise is a subset of physical activity that is planned for the purpose of keeping the body active. There is evidence that physical activity can lower the risk of chronic diseases such as diabetes (CDC, 2019).

Physical activity is characterized into vigorous, intensive and moderate. Research shows that regular physical activity of at least 150 minutes/week of moderate is important. (CDC, 2019).

Joshua et al (2016) examined the association between physical activity and T2D among various ethnic groups. This study was conducted using the Multi-Ethnic Study of Atherosclerosis (MESA) Physical activity survey, a population-based sample of gender from the 4 ethnic groups (Non-Hispanic Whites (NHW), African Americans (AA). Chinese Americans (CA) and Hispanic Americans (HA). Variables such as moderate – vigorous physical activity, intensive exercise and sedentary behavior was used and categorized into quartiles. Vigorous PA was associated with a reduction in type 2 diabetes risk in NHW by 35%, with non-significant reductions in CA by 6%, AA by 12% and HA by 13%. The study eventually concluded that there is an inverse relationship with between T2D and vigorous activity and a positive association with sedentary behaviors. The authors concluded that these associations could potentially vary by race that further studies should include a larger sample size.

Two randomized control trial conducted showed that lifestyle modifications including approximately 150min/week of physical activity and diet with a weight loss of 5-7% reduced the risk of impaired glucose tolerance progressing to T2D (Sigal, 2006).

Randomized trials have shown that physical activity can reduce the incidence of T2D but the intensity of the studies need to be stated since moderately physical activity has not been studied (Colberg, 2016). One of the recommendations from ADA is that adults with diabetes should perform aerobic and exercise training to achieve optimal health and glycemic outcomes (Colberg, 2016).

A study conducted in Pakistan examined the effect of physical activity and obesity among middle-aged population (45-64) using a physical activity questionnaire on regular exercise and sports participation for 2 years. Using Cox proportional hazard model, it was concluded that leisure-time physical activity and other types of physical activities were associated with a reduced risk of type-2 diabetes (Ansari, 2009).

Also, a study on female registered nurses within between 34-59 years who reported vigorous exercises at least once a week, showed a decreased incidence of type-2 diabetes during an 8-year follow up than women who did not exercise weekly (Manson et al 1991).

2.3 Joint Occurrence of Obesity and Physical Inactivity

Few studies conducted have examined the joint association of obesity and physical inactivity with the risk of type 2 diabetes, but little information is known about the racial stratification.

It is been known that increase in obesity and physical inactivity can have an impact on obesity but not be detrimental to those who are physically fit. It is estimated that for every 1kg increase in weight, the prevalence of diabetes increases by 9%. Physical activity is associated with an increase in insulin resistance (Sullivan, 2005).

Also, in a systematic review, it was concluded that physical activity was associated with reduced risk of diabetes even after adjustment for body mass index (BMI); although this relation was attenuated (Jeon, 2007). Therefore, higher levels of physical activity need to be maximized to reduce the risk of diabetes in high-risk subjects such as the obese, especially those with positive family history of diabetes, or with impaired glucose tolerance.

CHAPTER III – **Methodology**

3.1 - Data Source

This study was conducted to evaluate the relationship between obesity and physical inactivity with diabetes among adults using the National health

and Nutrition Survey (NHANES 2015-2016). NHANES is a major part of the National center for health Statistics (NCHS) under the Centers for Diseases Control and Prevention (CDC). They have a vital responsibility of providing statistical records. Data collection occurs through interviews and are conducted in respondents' homes. The survey consists of a representative sample of about 5,000 persons each year. The components of the examination include medical, physiological measurements as well as laboratory tests administered by a medical professional (CDC, 2018).

3.2 - Variables

Dependent Variable

Diabetes: The basis of diagnosis for this dependent variable was the use of Hemoglobin A1c, or self-reported diabetes or diabetes medication to lower blood sugar level. The Hemoglobin A1c range was adapted from The American Diabetes Association which include (ADA, 2016).

1) < 5.7% was termed normal
2) 5.7% to 6.4% was termed "pre-diabetic"
3) ≥ 6.5 was termed "diabetic"

Independent variables

BMI: This body measurement estimates the prevalence of Type-2 diabetes of adults. The variable was calculated as weight in kilograms divided by height

in meters squared. BMI < 30 was recoded as “Not Obese” while BMI ≥30 was recoded as “Obese”.

Physical activity: The physical activity questionnaire termed is based on Global activity questionnaire and provides respondent-level interview data on physical activities. The variable was used so the question “Does vigorous-intensity activity cause large increase in breathing”? Also, “Does moderate-intensity activity cause small increase in heart rate for at least 10 minutes continuously”? Both variables were later merged and recoded for analysis. Physical activity was coded as 1 - “Physically active”; 2 - “Physically inactive”.

Socio-demographics Characteristics

Age – Age in years was reported during the data analysis. Survey participants include individuals above the age of 18 years.

Race/ethnicity: The variable was used, and “race” was recoded for simplicity. Non-Hispanic Blacks were recoded as “Blacks”, Non-Hispanic White were recoded as “White” while Mexican Americans/other Hispanics were used in the analysis.

Educational level- The education variable used in the analysis is the highest grade or level attained for 20+. The response categories were:

1.) Less than 9th grade education

2.) 9th - 11th education

3.) High school diploma/GED

4.) Some college or Associates Degree

5.) College graduate and higher

The variable was later recoded as - 1, 2 and 3: ≤ high school graduate; while 4 and 5 were ≥ high school graduate

Income level – The income variable represents the total annual household income in dollars

1) Less than $25,000
2) $25,000 - $74,999
3) $75,000+

Behavioral factors

Diet Behavior and Nutrition: The variable “how healthy is your diet”? was categorized based on the following:

1- Excellent
2- Very good
3- Good
4- Fair
5- Poor

These variables were later recoded as: 1- Excellent, 2-Good and 3-Poor.

Smoking: This provides a history of cigarette use, age at initiation or within the past 30 days and other related questions. The variable “Have u smoked at least 100 cigarettes in life” was used in the analysis.

3.3 - Inclusion and Exclusion criteria

The sample (N=5992) for this study focuses on individuals who are aged 18 years and older and had no missing responses to questions about their diabetes diagnosis status. Individuals who were less than 18 years were excluded from the study. Respondents were categorized as ‘Yes’ to who met the threshold for diabetes and ‘no’ to those who did not have diabetes.

3.4 - Statistical Procedure

Statistical Analysis System (SAS) studio (SAS®Studio version 3.71) was used to analyze the data. Descriptive statistics were used to examine the distribution of various demographic characteristics, and the independent and dependent variables. Univariate analysis using logistic regression was used to find the association in the joint occurrence of the two risk factors and the risk of type 2 diabetes. A multivariate analysis was conducted for the same purpose adjusting for age, smoking, educational level, gender, income and diet etc. A p-value of 0.05 was used to establish significant associations. The analysis was then carried out among race/ethnic groups to determine any difference between race groups.

Chapter 4 **- RESULTS**

4.1 **Descriptive Statistics**

The sample consisted of 5992 individuals who met the eligibility criteria. The demographic characteristic of the sample population based on the prevalence of diabetes as shown in Table 1. From the sample, 2016 (27.13%) of the respondents had diabetes while 3976 (72.87%) did not. Among those with diabetes, 56.75% were obese, compared with 43.25% of those who were non-obese and had diabetes ($p<0.0001$). Among those with the three racial groups, NHB was 17.68%, NHW, 63.3% and MA, 19.02% had diabetes. In the joint occurrence, 30.53% of the individuals had Type 2 diabetes compared to 16.18% of those who did not have diabetes.

Table 2 shows the demographic characteristic of the sample population stratified by race/ethnicity. It was evenly distributed among the sample population with Whites comprising of N=1914, Blacks, 1265 and Mexican Americans, 1860 of the study population. NHW accounted for 24.36% (N=533), NHB, 515(37.52%) versus 696 (29.72%) of MA with diabetes. Educational attainment was only statistically significant among Blacks and achieving a higher secondary education than other ethnic groups (79.42%, N=401) and $p=0.0021$. Age, BMI and smoking were significant ($p<0.0001$) across the three ethnic groups. However, diet, gender and physical inactivity did not show statistical significance after Chi-square analysis. Also, the coexistence of the risk factors was statistically significant across the three

racial groups with diabetes: NHW (N= 148, 27.33%), NHB (192, 38.25%) and MA (N=257, 35.88%).

4.2 **Univariable Analysis**

A univariable analysis was conducted to estimate the association between the participant characteristics stratified by race and diabetes status (Table 3). Among MA, individuals who were obese were 2.36 times more likely to have T2D when compared to those who were non -obese (95% CI: 1.78-3.18). Similar associations were observed among NHW and NHB. Age (35-49) among Blacks were 4.42 times more likely to have diabetes than other racial groups (95% CI:2.91-6.73). Educational attainment was significant between MAs and NHB with less than high school degree and were more likely to have diabetes than NHW.

4.3 **Multivariable analysis**

Table 3 also shows the multivariable analysis of the association between the participant characteristic stratified by race and diabetes. After adjusting for age, gender, income, diet, educational level and smoking, there were significant associations between obesity, physical inactivity and T2D among all three racial groups. For NHB, the increased odds of being obese and diabetic was 3.20 times the odds of not being obese and not having

diabetes. NHW (OR=0.95, 9%% CI: 0.65-1.39) had an increased odds of being physically inactive and having T2D compared to other racial groups. Table 4, there was a decrease in the joint occurrence of obesity and physical inactivity with Type 2 diabetes among MA (OR=1.70, 95% CI: 1.12-2.59).

Chapter 5 – Discussion and Conclusion

5.1 Discussion

The main focus of the study was to evaluate the association in the joint occurrence of obesity and physical inactivity with the risk of T2D stratified by race among individuals residing in the United States. An odds ratio of >1.0 from the multivariable analysis in this study showed an association of obesity and physical inactivity with the risk of T2D.

Based on the analysis conducted, 2016 (27.13%) of respondents were diagnosed with diabetes while 3976 (72.87%) did not have diabetes. Of the 27% with diabetes, MA accounted for 696 vs 515 Blacks. Physical activity was not statistically significant (0.15) nor gender (0.80) and its association with T2D.

When the data was stratified by race/ethnicity, Chi-square analysis revealed that 64.59% of NHB were physically inactive compared to MA (63.90%) or NHW, 51.58%. Among NHB obese individuals, 61.42% weighed more than

Whites and Mexican Americans. Multivariable analysis revealed that of those who were obese with Mexican Americans (OR=2.45, 95% CI: 1.58-3.80), NHB (OR=3.20, 95%CI: 2.08-4.93) and NHW (OR=2.71, 95% CI: 1.95-3.76), showed an increased odds in diabetes among NHB than other racial groups who were not obese. Using the multivariable analysis, among those who were physically inactive were Mexican Americans (OR=0.91, 95% CI: 0.64-1.04), NHW (OR=1.07, 95% CI: 0.65-1.39) and NHB (OR=0.87, 95% CI: 0.66-1.16). This shows that NHW had an increased odds of being physically inactive with the risk of T2D compared to other racial groups.

The joint occurrence of obesity and physical inactivity was associated with increased odds of type 2 diabetes in NHW (OR=1.81, 95% CI=1.11-2.97), NHB (OR: 2.33; 95% CI=1.74-3.11) and MA (OR=1.70, 95% CI=1.12-2.59) after adjusting for age, gender, educational level, income, diet and smoking. The odds of Type 2 diabetes among NHB who are obese and physically inactive is 2.33 times the odds of being Black and not obese and not physically inactive

From previous literature, Rana, Li et al (2007) conducted a prospective study to examine the individual and joint association of obesity and physical activity with the development of type 2 diabetes (N=68,907, aged 30-55 years) in female nurses. Using the Nurses health cohort study, they concluded that women who were obese and physically inactive had an increased risk of type 2 diabetes (RR=16.75,95% CI:13.99–20.04). However, a study conducted in Tehran, India examined the association of physical

activity with decreased risk of T2D among obese and non-obese individuals. The results showed that there was no significant relation between the physical activity and type 2 diabetes risk in obese subjects (OR=0.64; 95%CI: 0.30–1.39). This concludes that physical activity was significantly associated with decreased risk of type 2 diabetes in non-obese people.

From these observations, ethnicity not only affects susceptibility to diabetes, it does not also modify the effect of the risk factors of Type 2 diabetes. Some factors could be associated with ethnicity and T2D such as genetic predisposition, living conditions etc.

5.2 - Public Health Significance

The effect in the joint occurrence and T2D is consistent among racial groups. Therefore, addressing this outcome should be tailored towards these ethnic groups. First, interventions for marginalized groups such as Blacks and Mexican Americans may focus on social determinants of health such as access to health-care. Also, among Whites, public health interventions can be focused on lifestyle modifications such as change of diet etc.

5.3 - Limitations

One of the limitations of this study is that NHANES is a cross-sectional study design and as such cannot measure causality. Since this study included a large sample size, bias including measurement/sampling error; participants may have over or underestimated their BMI and self-reported data as basis of

diagnosis for diabetes. Other risk factors were not included in the analysis such as comorbidities or acculturation.

5.4 - Implications

The joint occurrence between obesity and physical inactivity indicates a positive association with the risk of T2D among the three racial groups.

5.5 - Conclusion/Future recommendations

Large disparities exist in the prevalence of obesity and diabetes among ethnic groups in the United States. In order to implement effective obesity or physical activity interventions, understanding these variations in the risk factors is of utmost importance. Therefore, public health interventions should implement communication measures in decreasing the risk of obesity and increasing physical activity. Specific intensities of physical activity should be examined as the type and duration which may play a role in reducing the risk for type 2 diabetes in NHBs.

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Table 1: Participant Characteristics and the risk of Type-2 diabetes using NHANES, 2015-2016

N(%)[a] = 5992 (100)				
	Total Sample	**Type II Diabetes Status**		**P-value**
Participant Characteristics	**N (%) = 5992 (100)**	**Yes 2016 (27.13)**	**No 3976 (72.87)**	
BMI				
Non-Obese	3416 (60.43)	899 (43.25)	2517 (67.07)	**<.0001[c]**
Obese	2246 (39.57)	1051 (56.75)	1195 (32.93)	
Physical Activity				
Active	2259 (45.34)	705 (43.03)	1554 (46.19)	0.15[c]
Inactive	3732 (54.66)	1311 (56.97)	2421 (53.81)	
Joint Occurrence				
Obese/Inactive PA	1330 (20.07)	648 (30.53)	682 (16.18)	**<.0001[c]**
Other groups*	4661 (79.93)	1368 (69.47)	3293 (83.82)	
Age				
Mean (Std)	47.21 (± 0.63)	58.08 (± 0.59)	43.16 (±0.66)	**<0.0001**
18-34	1749 (29.60)	132 (7.12)	1617 (37.97)	**<.0001[c]**
35-49	1418 (25.19)	365 (18.86)	1053 (27.54)	
50-64	1447 (25.33)	721 (38.17)	726 (20.55)	
65+	1378 (19.88)	798 (35.85)	580 (13.94)	
Race				
Mexican American	1862 (17.25)	696 (19.02)	1166 (16.60)	**0.0001[c]**
Non-Hispanic White	1914 (70.05)	533 (63.30)	1381 (72.54)	
Non-Hispanic Black	1265 (12.70)	515 (17.68)	750 (10.86)	
Gender				
Male	2887 (48.17)	993 (48.47)	1894 (48.06)	0.80[c]
Female	3105 (51.83)	1023 (51.53)	2082 (51.94)	
Education				
≤ High School	1364 (14.45)	614 (19.51)	750 (12.51)	**<.0001[c]**
> High School	4350 (85.55)	1391 (80.49)	2959 (87.49)	
Diet				
Excellent	508 (8.30)	156 (7.79)	352 (8.49)	
Good	3486 (62.94)	1118 (60.51)	2368 (63.85)	**0.04[c]**
Poor	1997 (28.76)	742 (31.71)	1255 (27.66)	
Smoking				
Yes	2422 (42.87)	922 (48.62)	1500 (40.73)	**<0.0001[c]**
No	3559 (57.13)	1090 (51.38)	2469 (59.27)	
Income				
Less than $25,000	1449 (17.43)	615 (23.87)	834 (15.07)	**<0.0001[c]**
$25,000 - $74,999	2295 (41.44)	763 (44.23)	1532 (40.42)	
$75,000+	1500 (41.12)	379 (31.90)	1121 (44.51)	

Abbreviations:
[a] All values N (%) unless otherwise stated
p-value indicates that the finding is statistically significant at $\alpha=0.05$ ($p< .05$)
[C]Chi-square analysis was used to test the association of variables

Table 2 shows Participant Characteristics of Type 2 Diabetes stratified by race using NHANES, 2015-2016

Participant Characteristics	Race								
	NHW N% =1914 (100)			NHB N (%)= 1265 (100)			MA N (%)= 1862 (100)		
	DM N (%) =533 (24.36)	No DM N (%) = 1381 (75.64)	p-value	DM N (%) = 515 (37.52)	No DM N (%) = 750 (62.48)	p-value	DM N (%) = 696 (29.72)	No DM N (%) = 1166 (70.28)	p-value
BMI Non-Obese Obese	241 (43.95) 276 (56.05)	880 (67.35) 418 (32.65)	**<0.0001[c]**	204 (38.58) 295 (61.42)	452 (63.73) 256 (36.27)	**<0.0001[c]**	280 (39.12) 395 (60.88)	650 (60.21) 421 (39.79)	**<0.0001[c]**
Physical Activity Active Inactive	242 (49.93) 703 (51.58)	291 (50.07) 677 (48.42)	0.63[c]	178 (35.41) 337 (64.59)	274 (38.67) 476 (61.33)	0.22[c]	219 (36.10) 477 (63.90)	392 (36.20) 774 (63.80)	0.97[c]
Joint Occurrence Obese/Inactive PA Other groups*	148 (27.33) 385 (72.67)	201 (15.04) 1179 (84.96)	**<0.0001[c]**	192 (38.25) 323 (61.75)	147 (19.32) 603 (80.68)	**<0.0001[c]**	257 (35.88) 439 (64.12)	273 (22.90) 893 (77.15)	**<0.0001[c]**
Age 18-34 35-49 50-64 65+	21 (4.13) 58 (13.09) 160 (39.58) 294 (43.20)	464 (32.08) 339 (26.70) 256 (23.45) 322 (17.77)	**<0.0001[c]**	41 (10.91) 124 (27.27) 198 (38.67) 152 (23.15)	333 (48.66) 204 (27.50) 131 (16.40) 82 (7.44)	**<0.0001[c]**	50 (12.66) 127 (31.04) 270 (34.36) 249 (21.95)	498 (51.02) 306 (30.16) 235 (14.13) 127 (4.69)	**<0.0001[c]**
Gender Male Female	290 (49.13)	681 (48.27)	0.77[c]	251 (44.91)	347 (44.59)	0.92[c]	313 (49.71)	527 (49.60)	0.96[c]

	243 (50.87)	700 (51.73)		264 (55.09)	403 (55.41)		383 (50.29)	639 (50.40)	
Education ≤ High School > High School	80 (10.75) 451 (89.25)	150 (7.23) 1181 (92.77)	0.078[c]	112 (20.58) 401 (79.42)	106 (13.76) 577 (86.24)	**0.002[c]**	354 (47.99) 337 (52.01)	405 (34.96) 665 (65.04)	**<0.0001[c]**
Diet Excellent Good Poor	57 (8.96) 327 (65.34) 149 (25.70)	131 (8.93) 903 (67.49) 346 (23.59)	0.64[c]	40 (7.13) 288 (55.29) 187 (37.59)	76 (9.03) 395 (52.69) 279 (38.29)	0.34[c]	32 (3.88) 322 (45.15) 342 (50.98)	74 (5.21) 601 (52.00) 491 (42.80)	**0.0039[c]**
Smoking Yes No	303 (53.98) 230 (46.02)	665 (44.64) 713 (55.36)	**<0.0001[c]**	238 (44.04) 275 (55.96)	283 (36.19) 465 (63.81)	**0.0041[c]**	285 (40.29) 409 (59.71)	377 (31.69) 787 (68.31)	0.0043[c]
Income Less than $25,000 $25,000 - $74,999 $75,000+	149 (18.05) 205 (43.23) 125 (38.72)	231 (10.59) 550 (37.95) 497 (51.46)	**<0.0001[c]**	165 (45.15) 189 (34.69) 95 (35.89)	188 (54.85) 305 (65.31) 150 (64.11)	**0.028[c]**	238 (32.79) 264 (49.93) 89 (17.28)	313 (28.20) 467 (48.05) 215 (23.75)	0.086[c]

Abbreviations:
NHW: Non-Hispanic Blacks
NHB: Non-Hispanic Whites
MA: Mexican Americans
Bold indicates that the finding is significant at α=0.05 (p< .05)

Table 3: Univariable and Multivariable analysis of participant characteristics stratified by race using NHANES, 2015-2016

Participant Characteristics	Race					
	NHW		NHB		MA	
	cOR (95%CI)	aOR (95%CI)	cOR (95%CI)	aOR (95%CI)	cOR (95%CI)	aOR (95%CI)
BMI Not Obese Obese	Referent **2.63 (2.04 – 3.40)**	Referent **2.71(1.95-3.76)**	Referent **2.80 (2.10 – 3.72)**	Referent **3.20(2.08-4.93)**	Referent **2.36 (1.74 -3.18)**	Referent **2.45(1.58-3.80)**
Physical Activity Active Inactive	Referent 1.07(0.81-1.41)	Referent 0.95(0.65-1.39)	Referent 1.15(0.91-1.45)	Referent 0.87(0.66-1.16)	Referent 1.00(0.79-1.28)	Referent 0.81(0.64-1.04)
Age 18-34 35-49 50-64 65+	Referent **3.81(2.40-6.05)** **13.10(7.71-22.28)** **18.87(11.24-31.68)**	Referent **4.03(2.26-7.19)** **14.91(8.22-27.05)**	Referent **4.42(2.91 -6.73)** **10.52(6.66**	Referent **3.94(2.46-6.33)** **11.29(7.06-**	Referent **4.15(3.03 -5.67)** **9.80(6.88**	Referent **3.57(2.26-5.65)** **8.69(5.80-13.00)**

Participant Characteristics	Race					
	NHW		NHB		MA	
	cOR (95%CI)	aOR (95%CI)	cOR (95%CI)	aOR (95%CI)	cOR (95%CI)	aOR (95%CI)
		22.40(12.53-40.04)	**-16.23) 13.87(7.80 -24.66)**	**18.05) 15.45(7.05-33.88)**	**-13.95) 18.85(13.18 - 26.98)**	**21.90(15.65-30.62)**
Gender Male Female	1.04(0.81-1.32) Referent	1.17(0.88-1.55) Referent	1.01(0.80-1.29) Referent	**1.54(1.17-2.03)** Referent	**1.00(0.83-1.22)** Referent	1.12(0.87-1.43) Referent
Diet Excellent Good Poor	Referent 0.97(0.62-1.50) 1.09(0.68-1.74)	Referent 1.33(0.80 -2.20) 1.46(0.78 -2.72)	Referent 1.32(0.96-1.83) 1.24(0.90-1.72)	Referent 1.44(0.95-2.19) 1.49(0.84-2.63)	Referent 1.17(0.73-1.85) 1.60(0.98-2.61)	Referent **1.66(1.00-2.75)** **2.20(1.12-4.30)**
Smoking Yes No	**1.45(1.19-1.78)** Referent	1.01(0.79-1.29) Referent	**1.39(1.08-1.78)** Referent	0.79(0.55-1.12) Referent	**1.46(1.11-1.90)** Referent	1.08(0.78-1.51) Referent
Income Less than $25,000 $25,000 - $74,999 $75,000+	**2.27(1.67-3.08)** **1.51(1.21-1.89)** Referent	**1.51(1.05-2.17)** 1.24(0.96-1.60) Referent	1.47(0.98-2.12) 0.95(0.61-1.48) Referent	**2.02(1.24-3.31)** 1.19(0.75-1.87) Referent	1.60(0.95-2.70) 1.43(0.98-2.09) Referent	1.16(0.70-1.93) 1.44(0.96-2.17) Referent

Abbreviations:
NHW: Non-Hispanic Blacks
NHB: Non-Hispanic Whites
MA: Mexican Americans
Bold indicates that the finding is significant at α=0.05 (p< .05)

Table 4: Joint Occurrence of Obesity and Physical Inactivity with the risk of Type 2 diabetes stratified by race, NHANES 2015-2016

Participant Characteristics	**Race**				
	Overall sample		**NHW**	**NHB**	**MA**
	cOR (95% CI)	**aOR (95% CI)**	**aOR (95%CI)**	**aOR (95%CI)**	**aOR (95%CI)**
Joint Occurrence Obese/Inactive PA Other groups*	**2.28(1.78-2.91)** Referent	**2.03(1.50-2.75)** Referent	**1.81(1.11-2.97)** Referent	**2.33(1.74-3.11)** Referent	**1.70(1.12-2.59)** Referent
Age 18-34 35-49 50-64 65+	Referent **3.65(2.94-4.53)** **9.90(7.54-13.00)**	Referent **3.59(2.83-4.56)** **10.24(7.82-**	Referent **4.16(2.42-7.15)** **14.58(8.03-26.47)**	Referent **4.35(2.84-6.65)** **11.03(7.20-16.92)** **12.79(6.53-25.06)**	Referent **3.30(2.15-5.04)** **8.18(5.30-12.64)** **18.53(13.23-25.94)**

Participant Characteristics	Race				
	Overall sample		NHW	NHB	MA
	cOR (95% CI)	aOR (95% CI)	aOR (95%CI)	aOR (95%CI)	aOR (95%CI)
Joint Occurrence Obese/Inactive PA Other groups*	**2.28(1.78-2.91)** Referent	**2.03(1.50-2.75)** Referent	**1.81(1.11-2.97)** Referent	**2.33(1.74-3.11)** Referent	**1.70(1.12-2.59)** Referent
	13.71(10.17-18.48)	**13.41) 14.64(10.97-19.52)**	**21.69(12.14-38.73)**		
Gender Male Female	1.02(0.89-1.16) Referent	**1.24(1.04-1.49)** Referent	1.22(0.91-1.62) Referent	**1.41(1.07-1.87)** Referent	1.18(0.92-1.50) Referent
Education ≤ High School > High School	**1.70(1.30-2.21)** Referent	1.31(0.98-1.74) Referent	1.31(0.75-2.28) Referent	1.12(0.70-1.78) Referent	1.06(0.84-1.33) Referent
Diet Excellent Good Poor	Referent 1.03(0.77-1.39) 1.25(0.90-1.73)	Referent **1.41(1.01-1.97)** **1.87(1.24-2.80)**	Referent 1.38(0.82-2.28) 1.67(0.91-3.07)	Referent **1.63(1.09-2.44)** **1.91(1.15-3.17)**	Referent **1.73(1.06-2.82)** **2.52(1.32-4.81)**
Smoking Yes No	**1.38(1.20-1.59)** Referent	0.91(0.77-1.09) Referent	1.02(0.80-1.29) Referent	0.78(0.54-1.13) Referent	1.08(0.78-1.51) Referent
Income Less than $25,000 $25,000 - $74,999 $75,000+	**2.21(1.75-2.79)** **1.53(1.26-1.85)** Referent	**1.88(1.44-2.47)** **1.49(1.15-1.91)** Referent	**1.58(1.15-2.15)** **1.31(1.00-1.72)** Reference	**1.93(1.19-3.13)** 1.17(0.74-1.86) Referent	1.20(0.73-1.98) 1.43(0.94-2.16) Referent

Participant Characteristics	Race				
	Overall sample		NHW	NHB	MA
	cOR (95% CI)	aOR (95% CI)	aOR (95%CI)	aOR (95%CI)	aOR (95%CI)
Joint Occurrence Obese/Inactive PA Other groups*	**2.28(1.78-2.91)** Referent	**2.03(1.50-2.75)** Referent	**1.81(1.11-2.97)** Referent	**2.33(1.74-3.11)** Referent	**1.70(1.12-2.59)** Referent
Abbreviations: NHW: Non-Hispanic Blacks NHB: Non-Hispanic Whites MA: Mexican Americans **Bold** indicates that the finding is significant at α=0.05 (p< .05)					